Biogeochemical cycles and conditions for photic zone euxinia in the ocean

*Eiichi Tajika[1], Kazumi Ozaki[2], Kana Oide[1]

1.Department of Complexity Science and Engineering, Graduate School of Frontier Sciences, The University of Tokyo, 2.Atmosphere and Ocean Research Institute, The University of Tokyo

Ocean anoxic events (OAEs) have occurred repeatedly during the Phanerozoic. Sedimentological studies have revealed that there was sometimes hydrogen sulfide in the water column, which is called ocean euxinia. Organic geochemical studies of black shales deposited at some of OAEs have revealed the presence of a specific molecule (biomarker) isorenieratane which is derived from green sulfur bacteria. Because these obligatory anaerobic photoautotrophic bacteria require both the light and hydrogen sulfide, it is indicated that there was hydrogen sulfide in photic zone (an uppermost 100~200 m of the surface ocean) at that time. This is remarkable because the photic zone is usually oxic owing to mixing with the overlying atmosphere which contains molecular oxygen as much as that of today throughout the most of the Phanerozoic. The condition and mechanism to cause such a photic zone euxinia (PZE) have been largely unknown. In order to understand PZE, we model the physical-chemical water column structure and the biogeochemical processes for the surface ocean. A new one-dimensional marine ecosystem-biogeochemical model, which has a high vertical resolution of ~5 m, was developed, and a series of parameter studies were performed. We found that the depth of chemocline (= the depth of dissolved oxygen/hydrogen sulfide boundary) resides at around 150 m which is determined by the limit of photosynthesis of algae due to light and also by the use of hydrogen sulfide due to green sulfur bacteria. We also found that the PZE is caused when the concentration of phosphate in seawater is higher than 8 mM which corresponds to the riverine flux of ~2.5 times the present value for the pelagic zone, while at the coastal upwelling regions PZE would be achieved when phosphate is higher than 5 mM which corresponds to the riverine flux of 2.1 times the present value. The riverine phosphate is derived from continents through chemical weathering, hence these two estimates correspond to the climatic conditions of 6 K and 11 K warmer than it is today, respectively. This result is consistent with the case of OAE2 (in the mid-Cretaceous, about 95 Ma) which occurred at the period of climate warming

Keywords: photic zone euxinia, ocean anoxic event, biogeochemical cycle

©2016. Japan Geoscience Union. All Right Reserved.